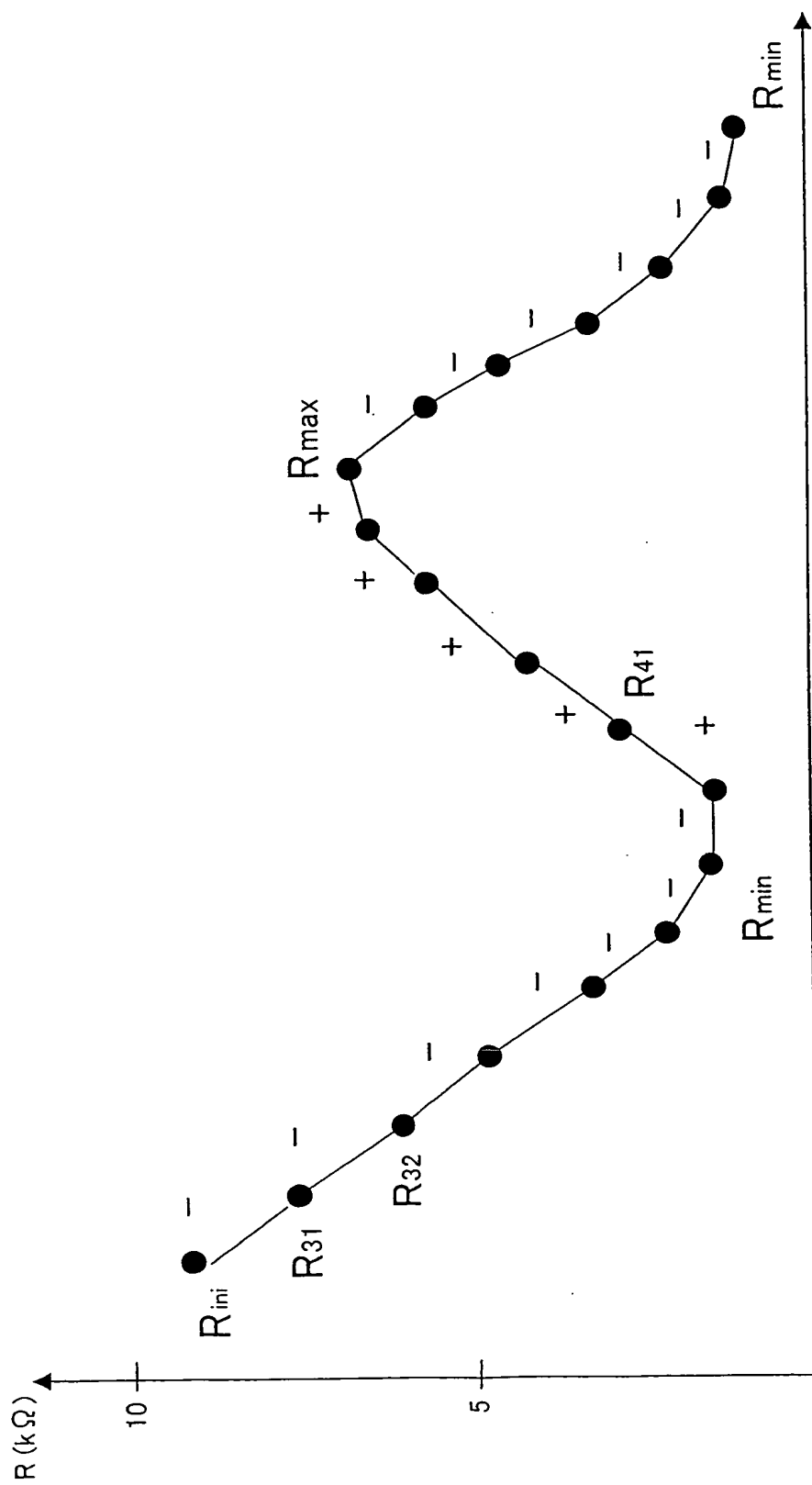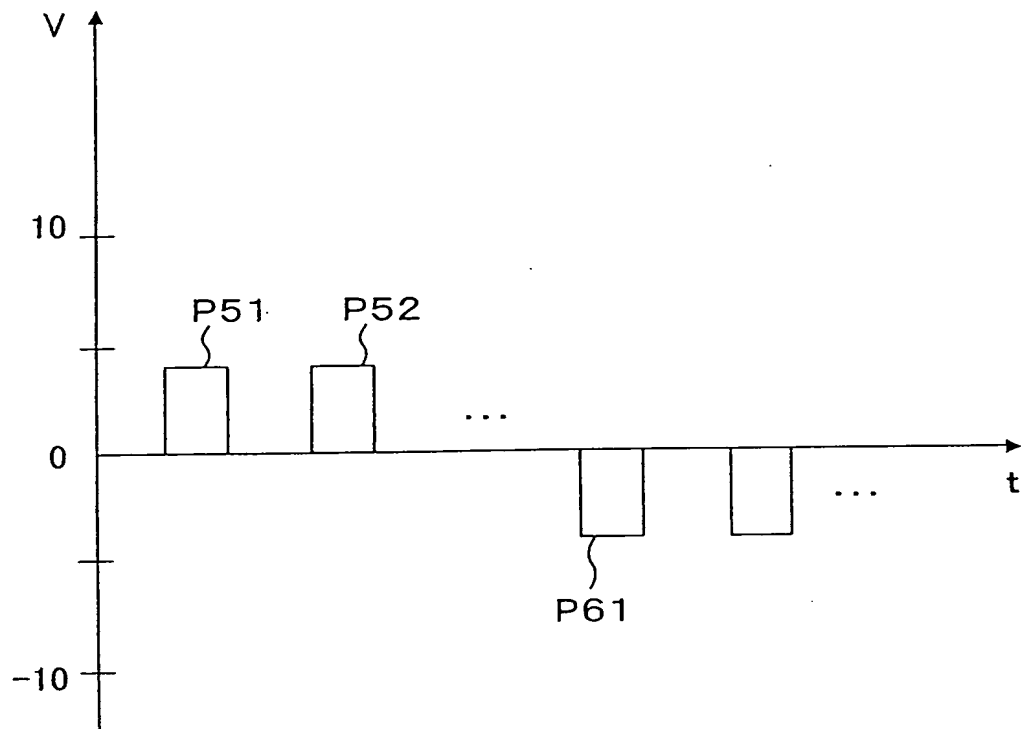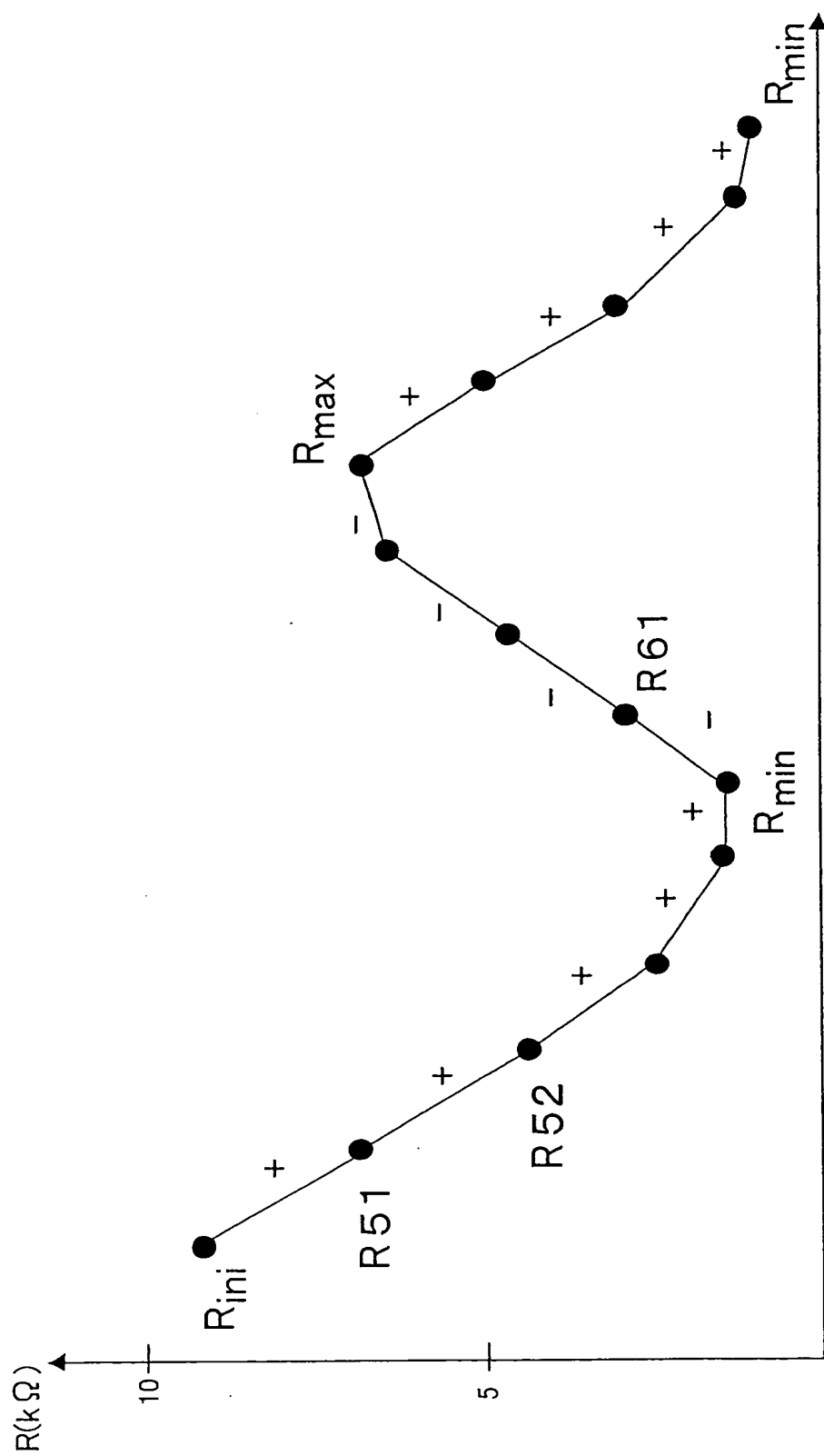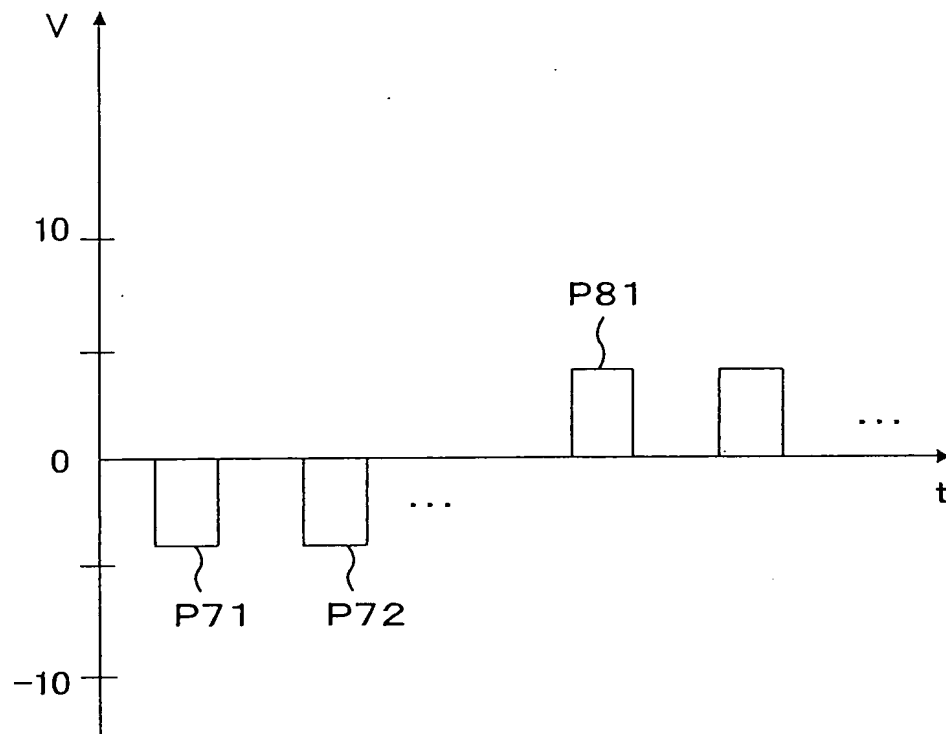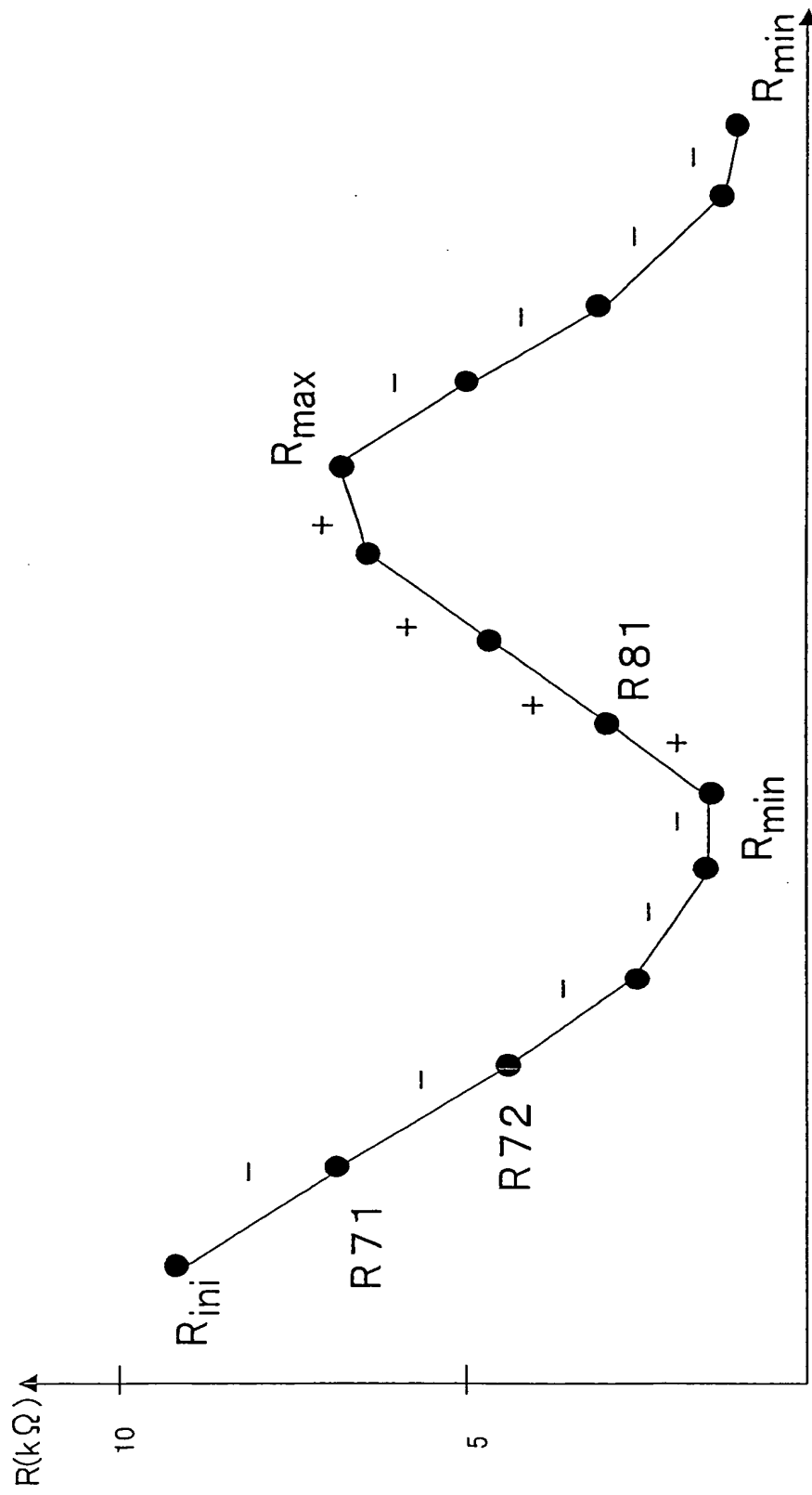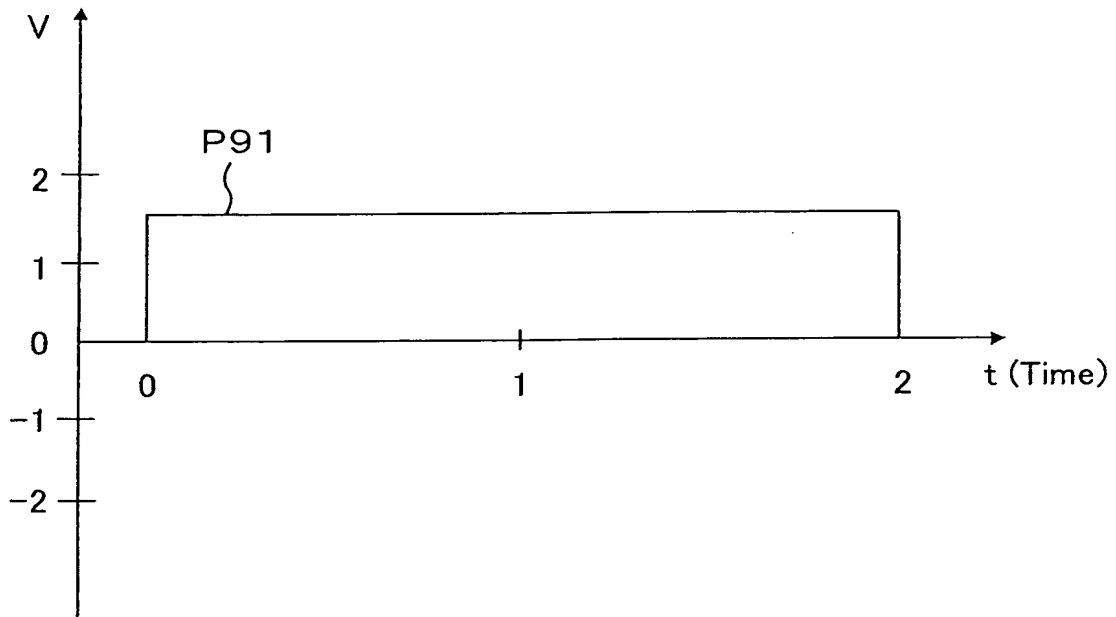# FIG. 1



# FIG. 2

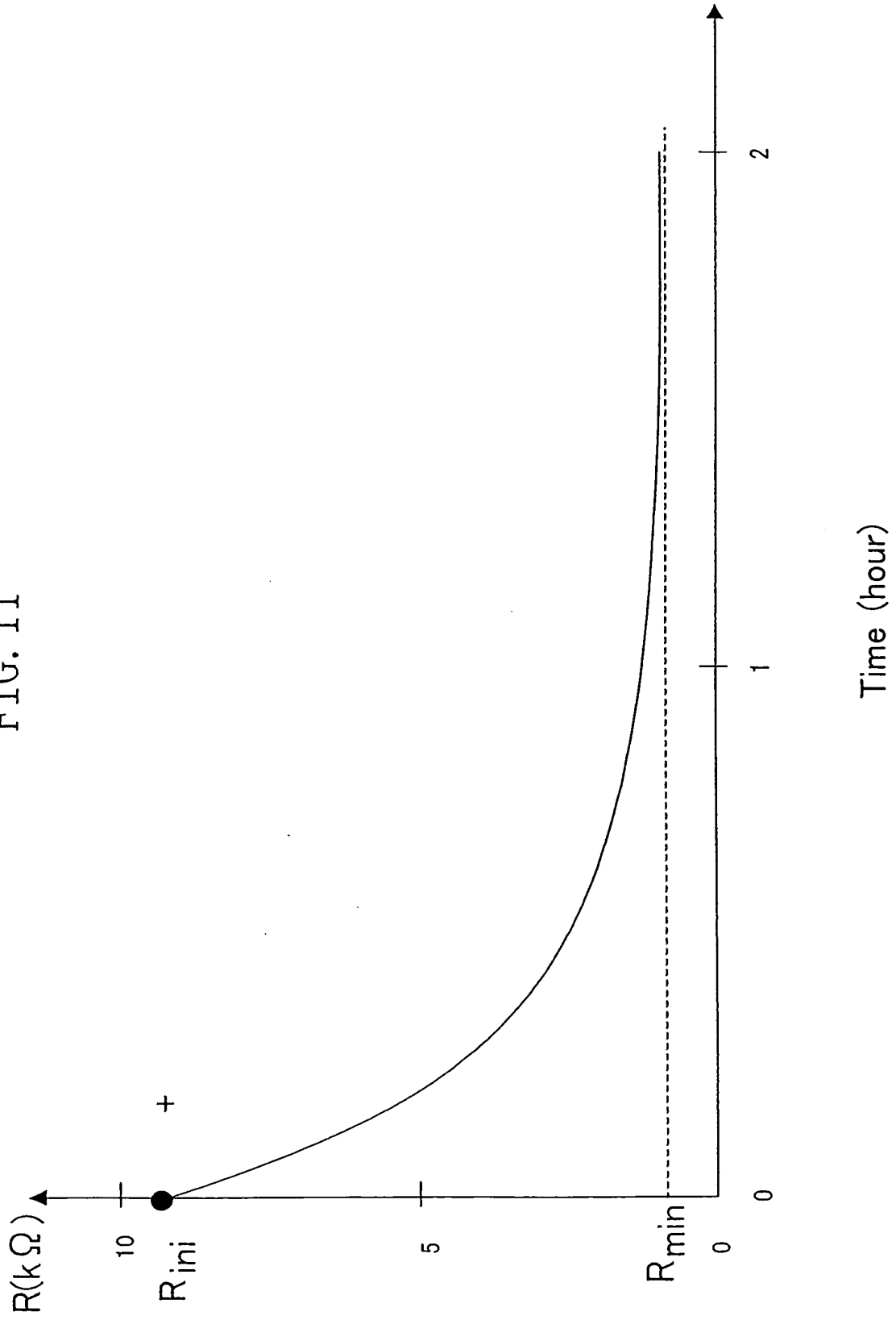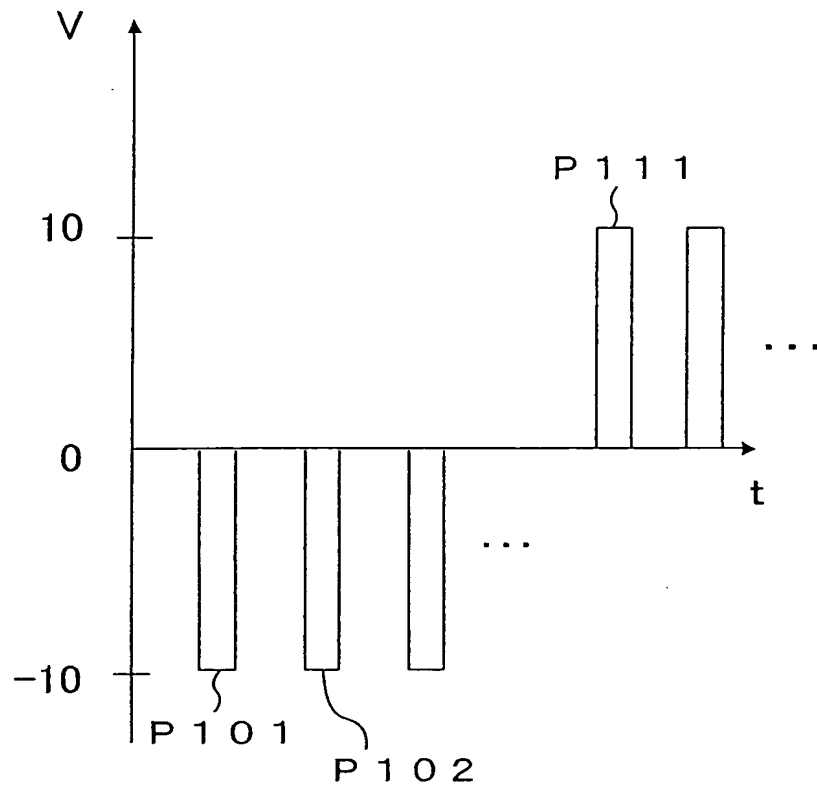# FIG. 3

# FIG. 4

# FIG. 5

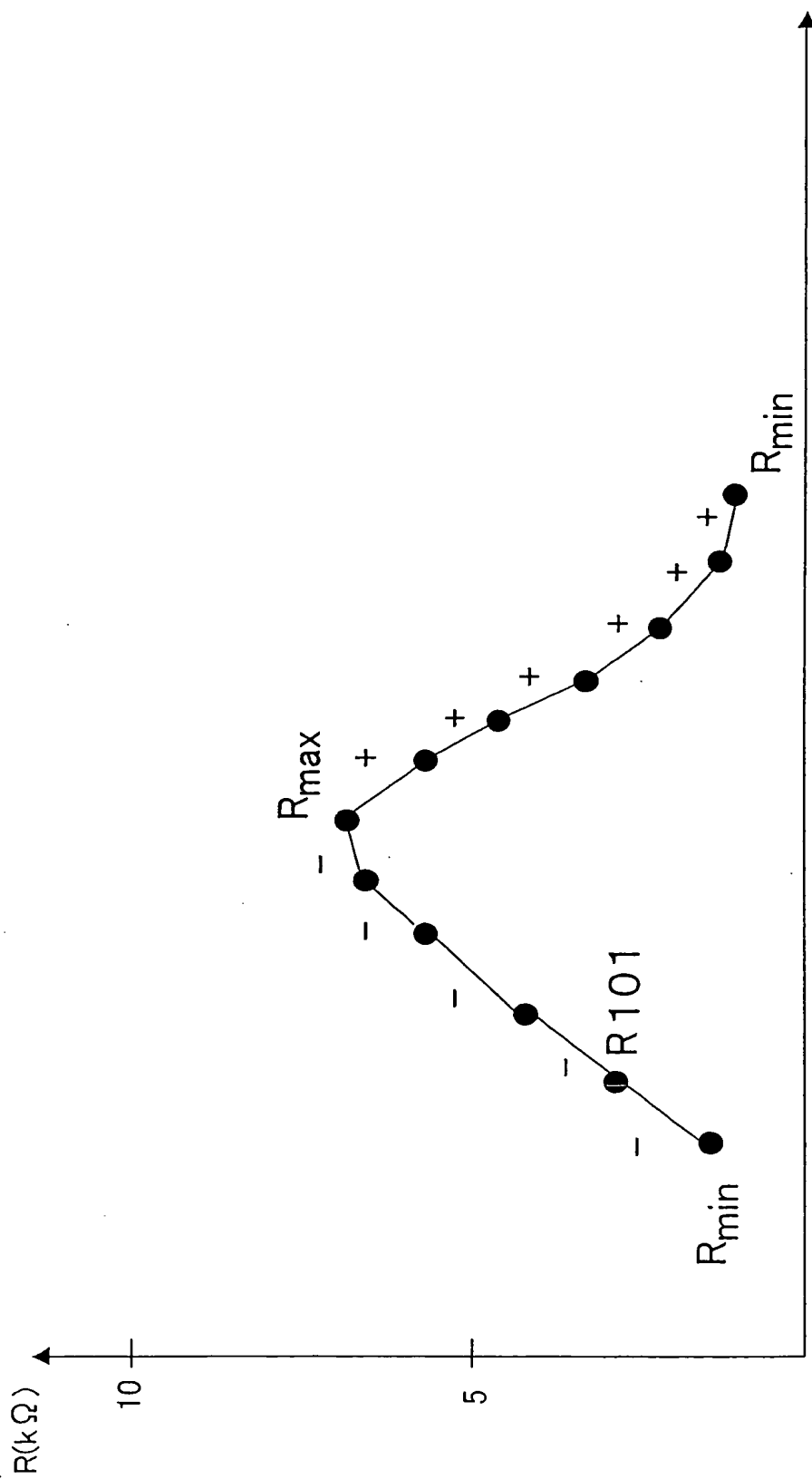# FIG. 6

# FIG. 7

# FIG. 8

FIG.9

# FIG. 10

FIG. 11

# FIG. 12

FIG. 13

# FIG. 14
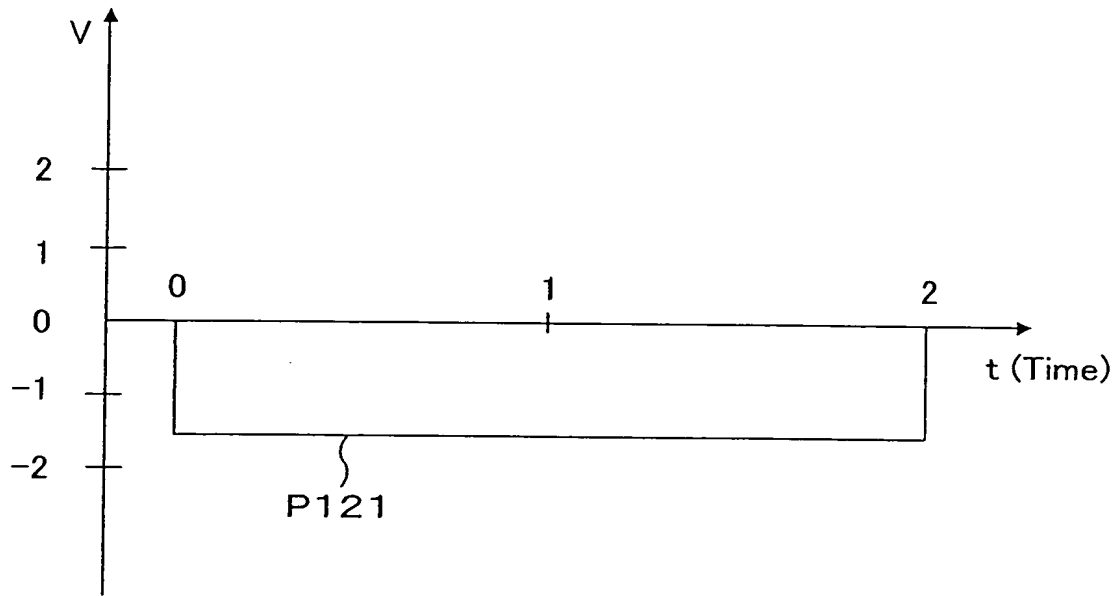
FIG. 15
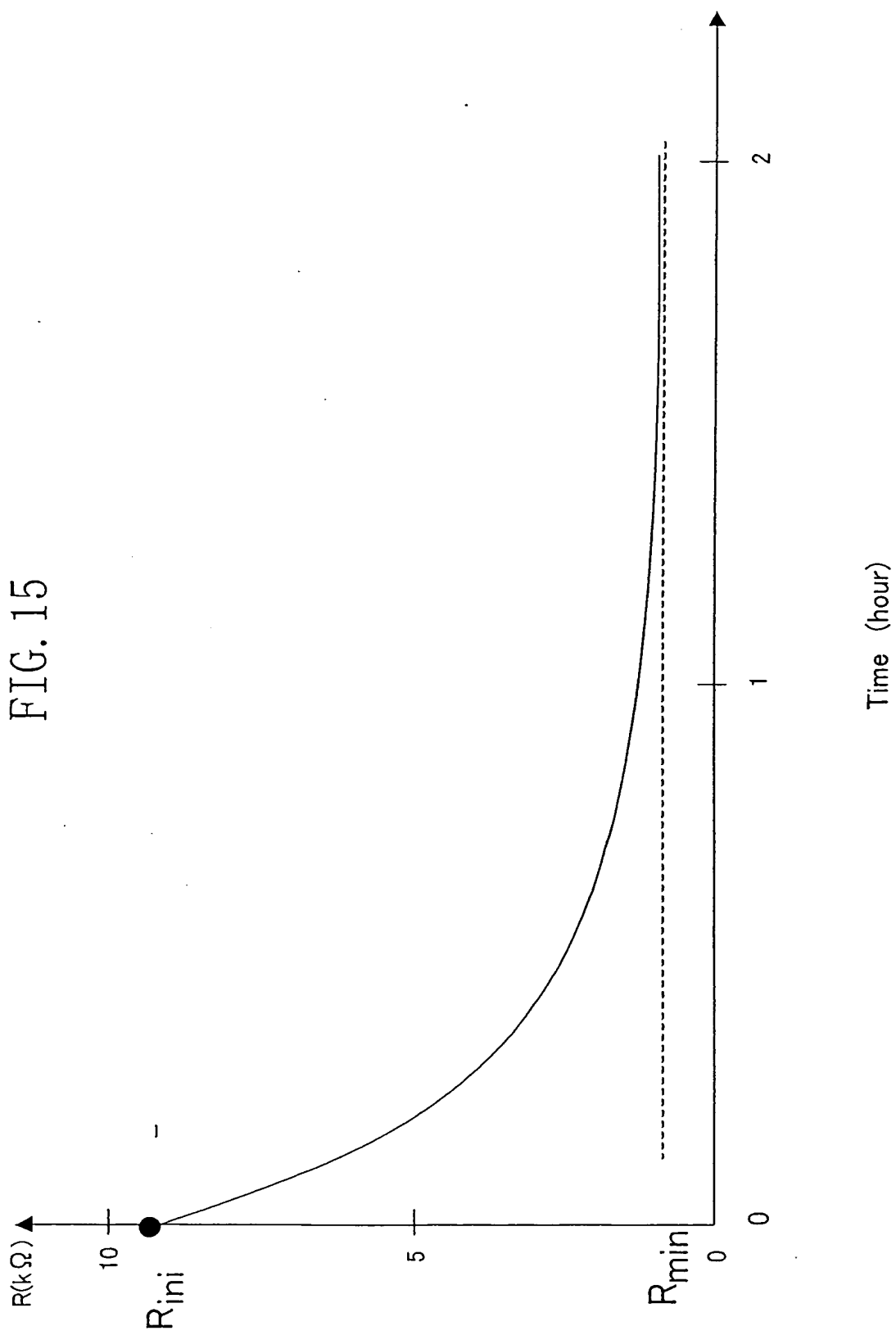
# FIG. 16
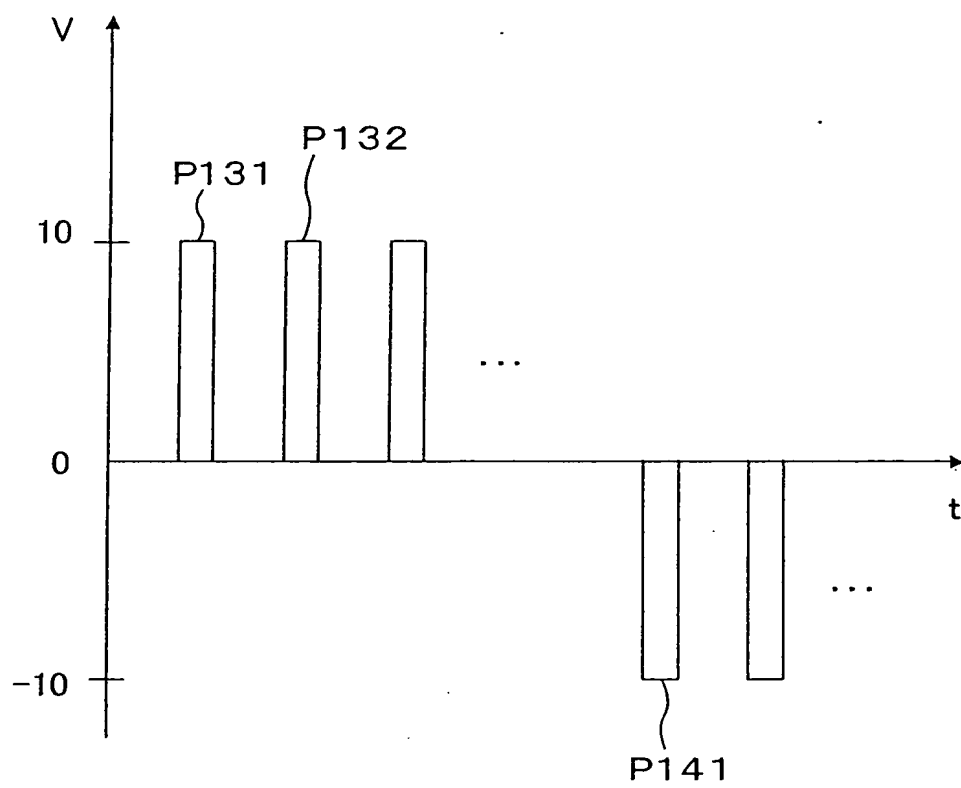
FIG. 17
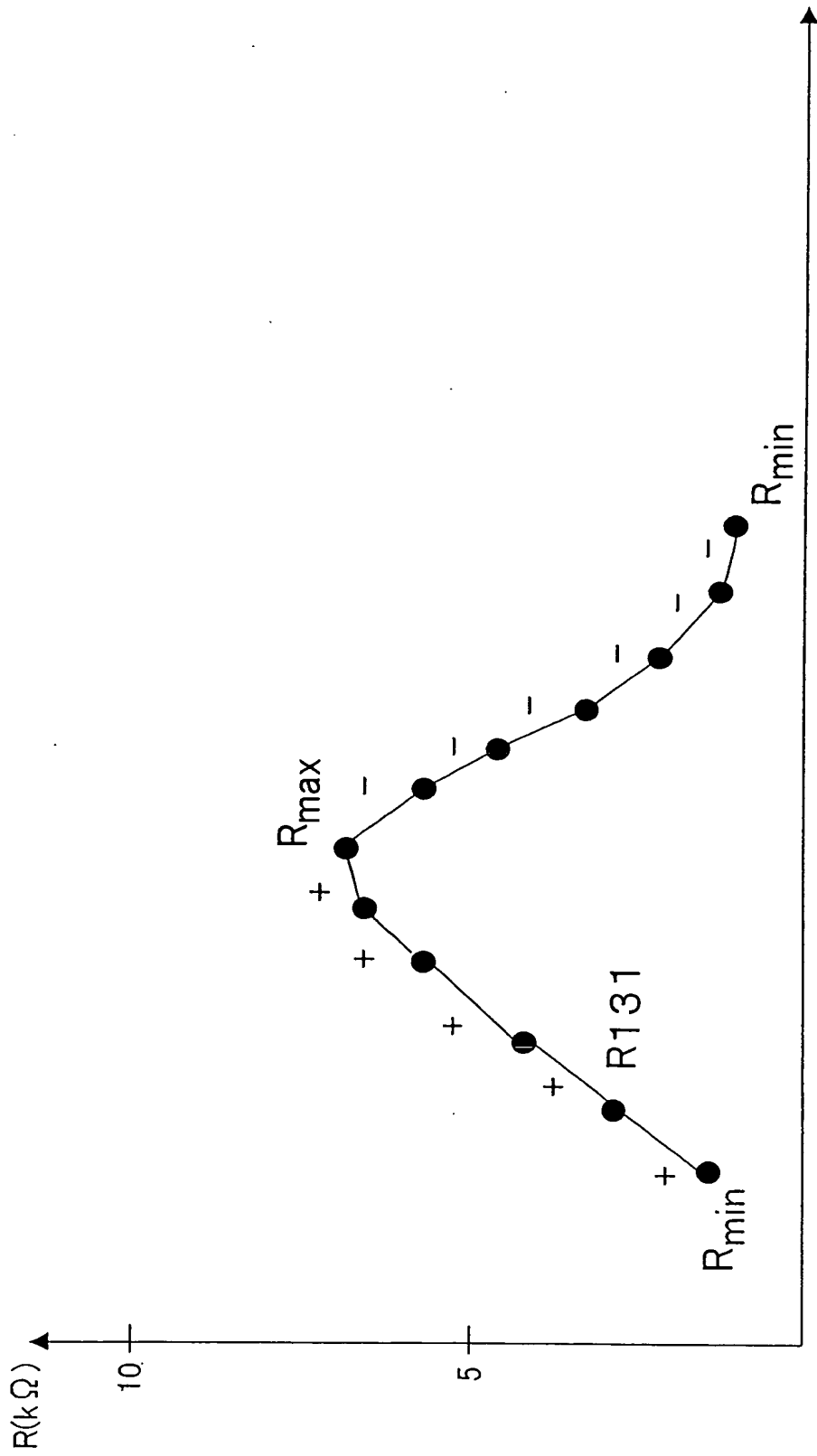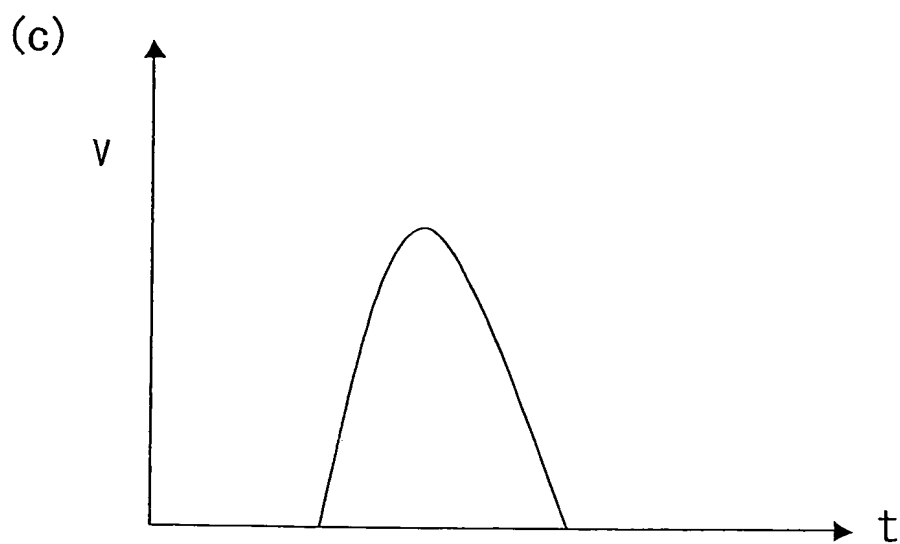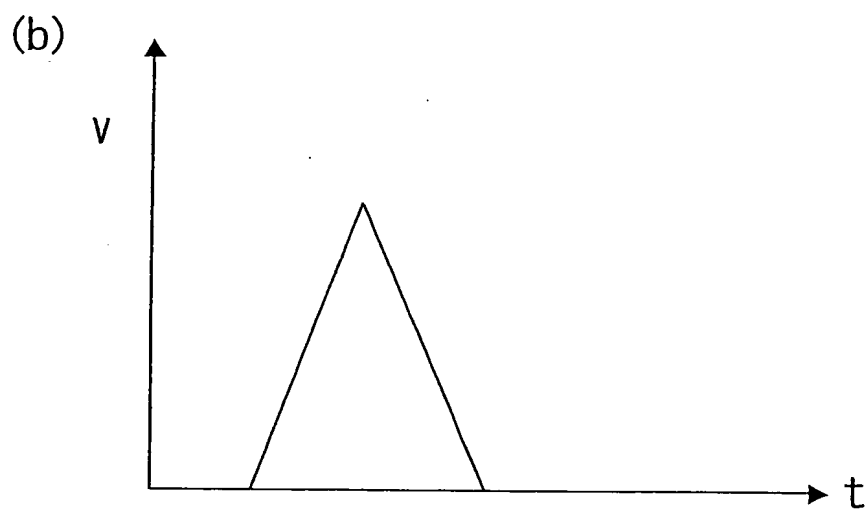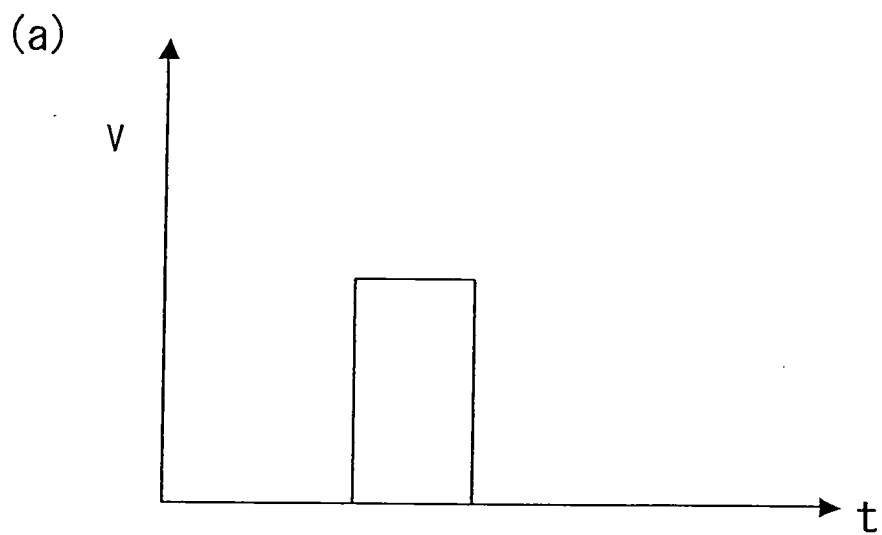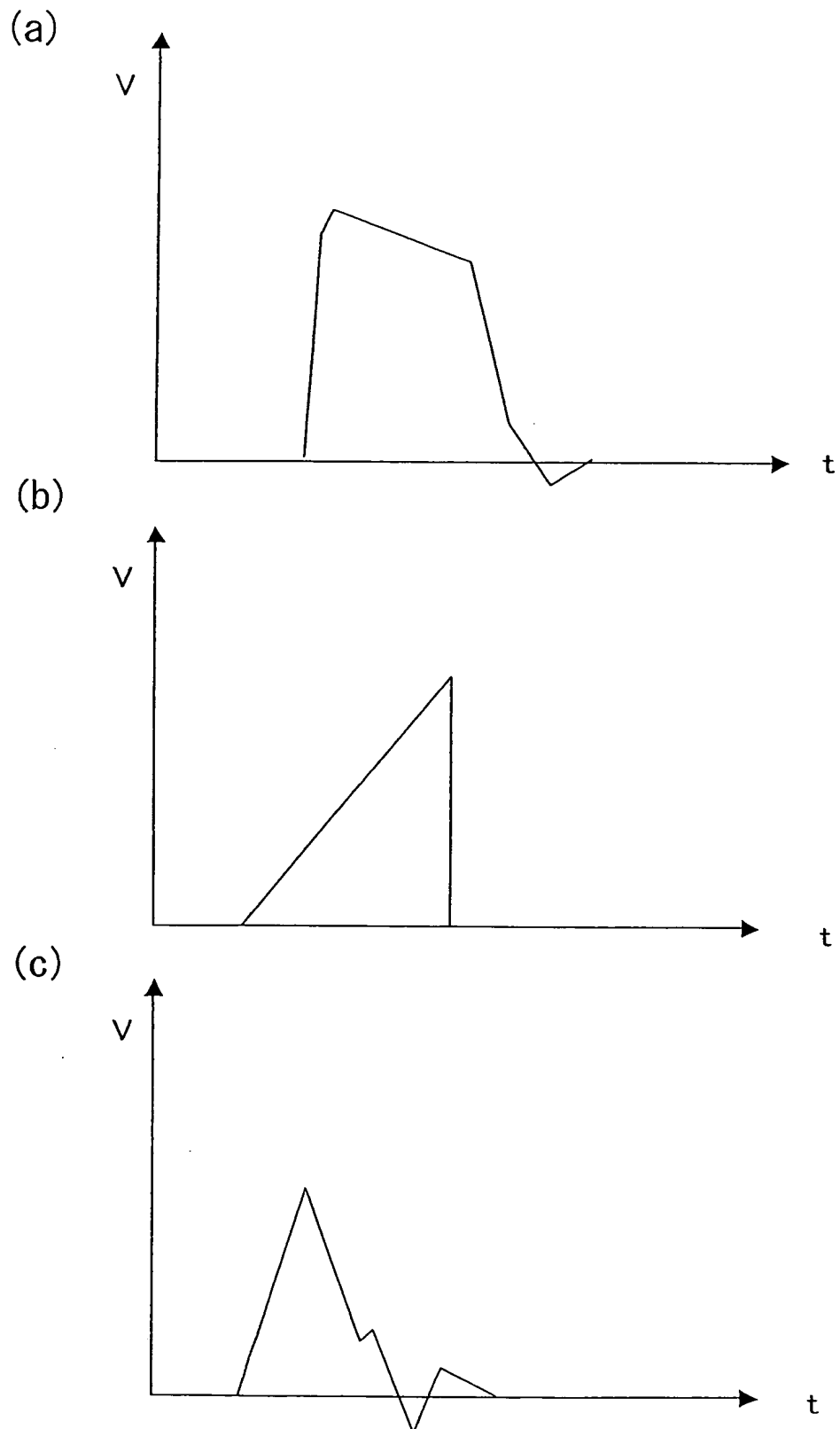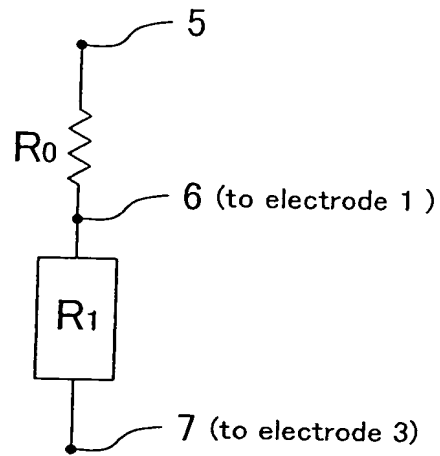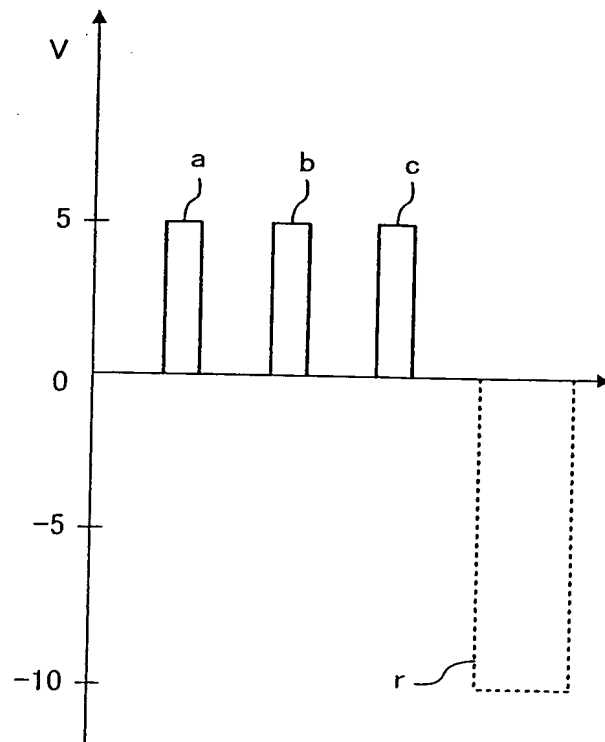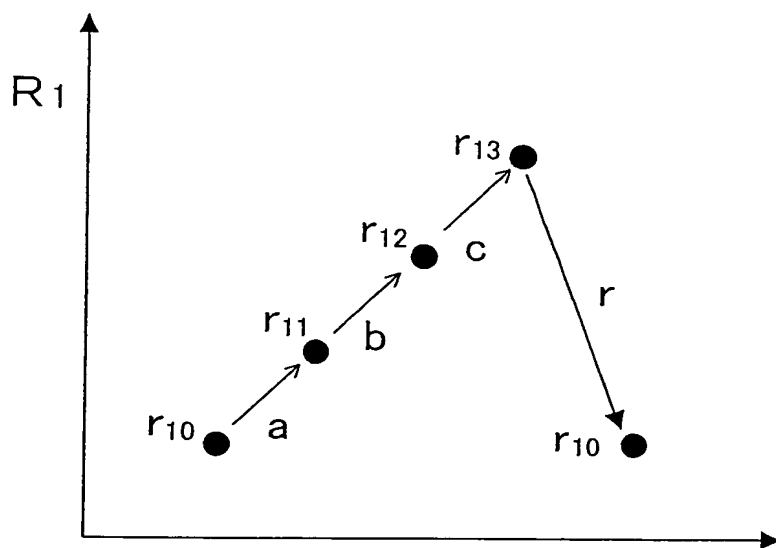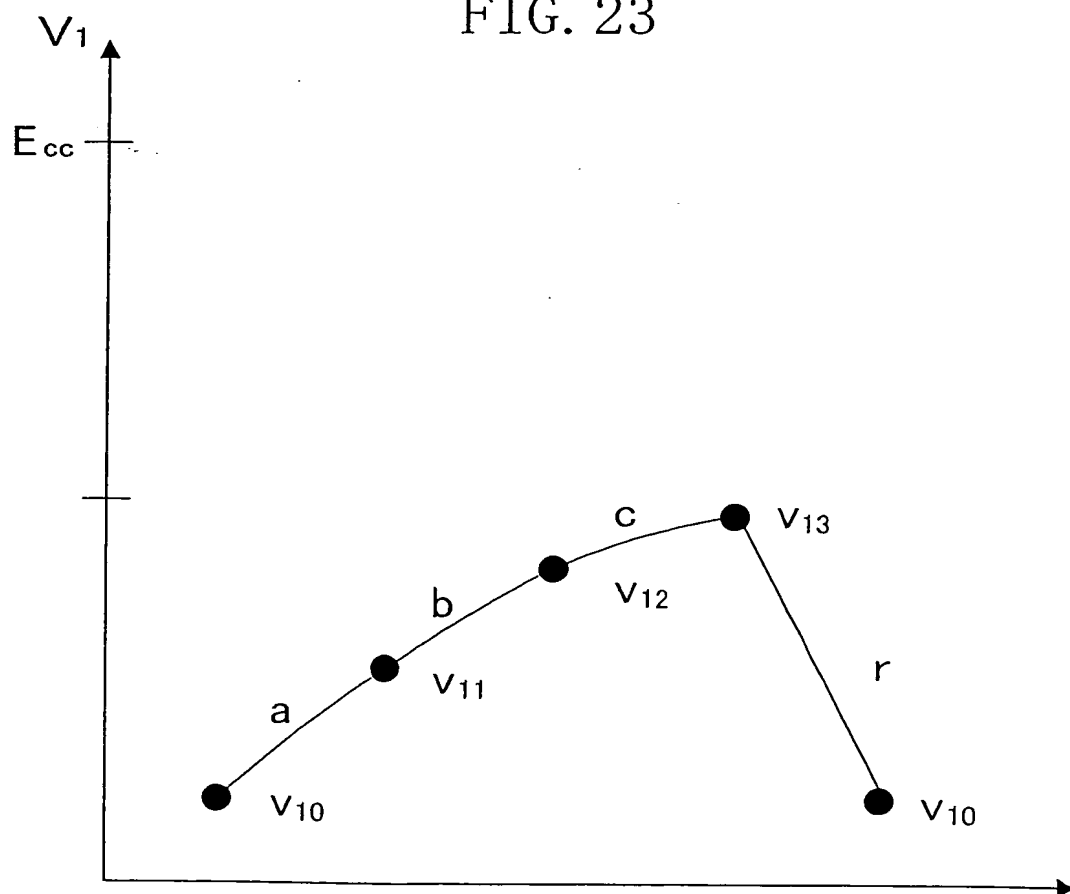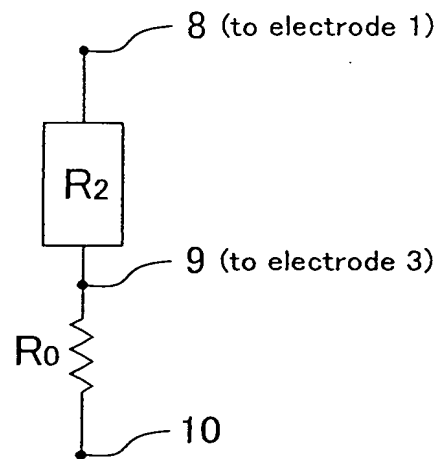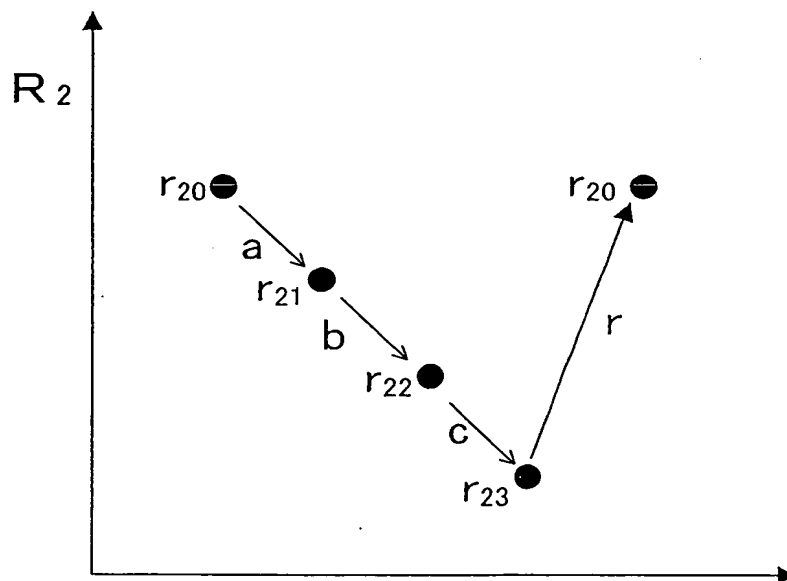


R(kΩ)

10

5

$R_{max}$

$R_{min}$

$R_{min}$

R131

# FIG. 18

(a)



(b)



(c)

# FIG. 19

(a)



(b)



(c)

# FIG. 20



5

$R_0$

6 (to electrode 1 )

$R_1$

7 (to electrode 3)

# FIG. 21



V

a    b    c

5

0

−5

r

−10

FIG. 22



FIG. 23

# FIG. 24

8 (to electrode 1)

$R_2$

9 (to electrode 3)

$R_0$

10

# FIG. 25

$R_2$

$r_{20}$

a

$r_{21}$

b

$r_{22}$

c

$r_{23}$

$r_{20}$

r

# FIG. 26

# FIG. 27

# FIG. 28

(a)



(b)

Symbol of variable resistor     Symbols after initialization





Pulse voltage : −2V    +2V    −2V

Initial value 9kΩ

Initial value 100Ω
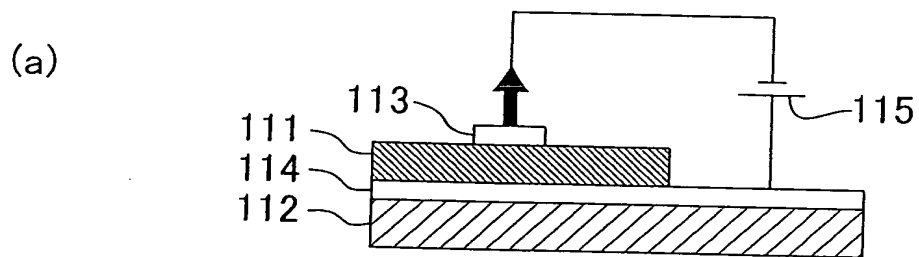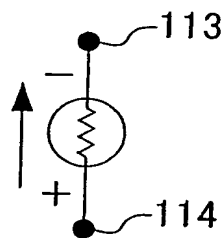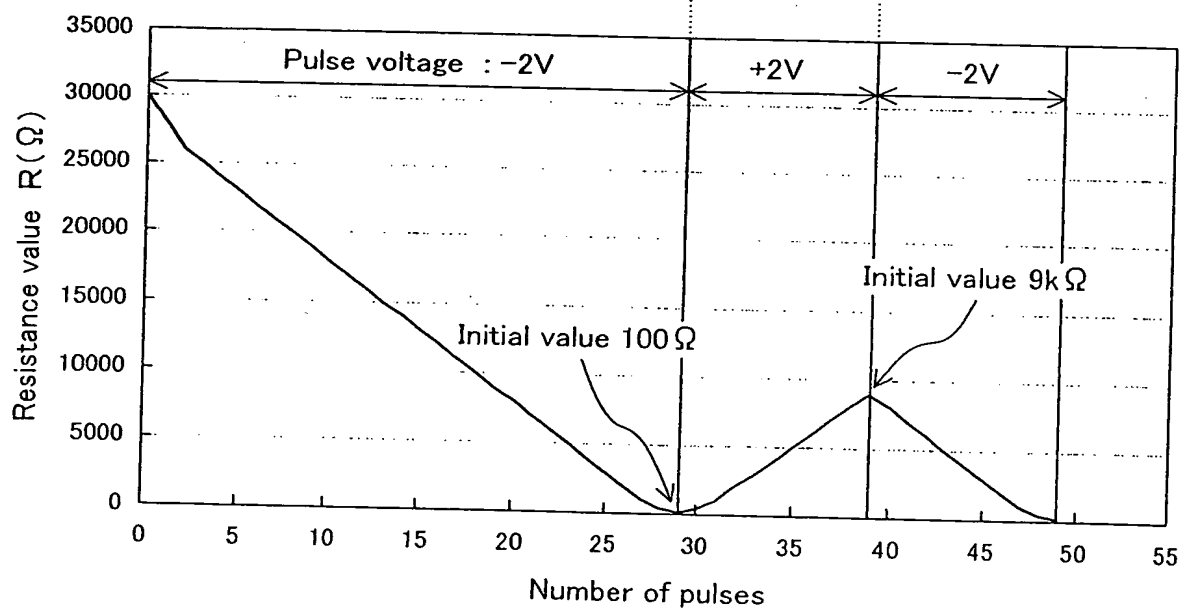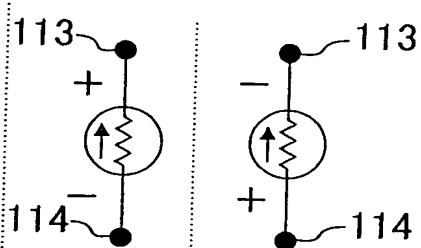
Number of pulses

# FIG. 29

(a)



(b)

Symbol of variable resistor          Symbols after initialization

# FIG. 30

(a)



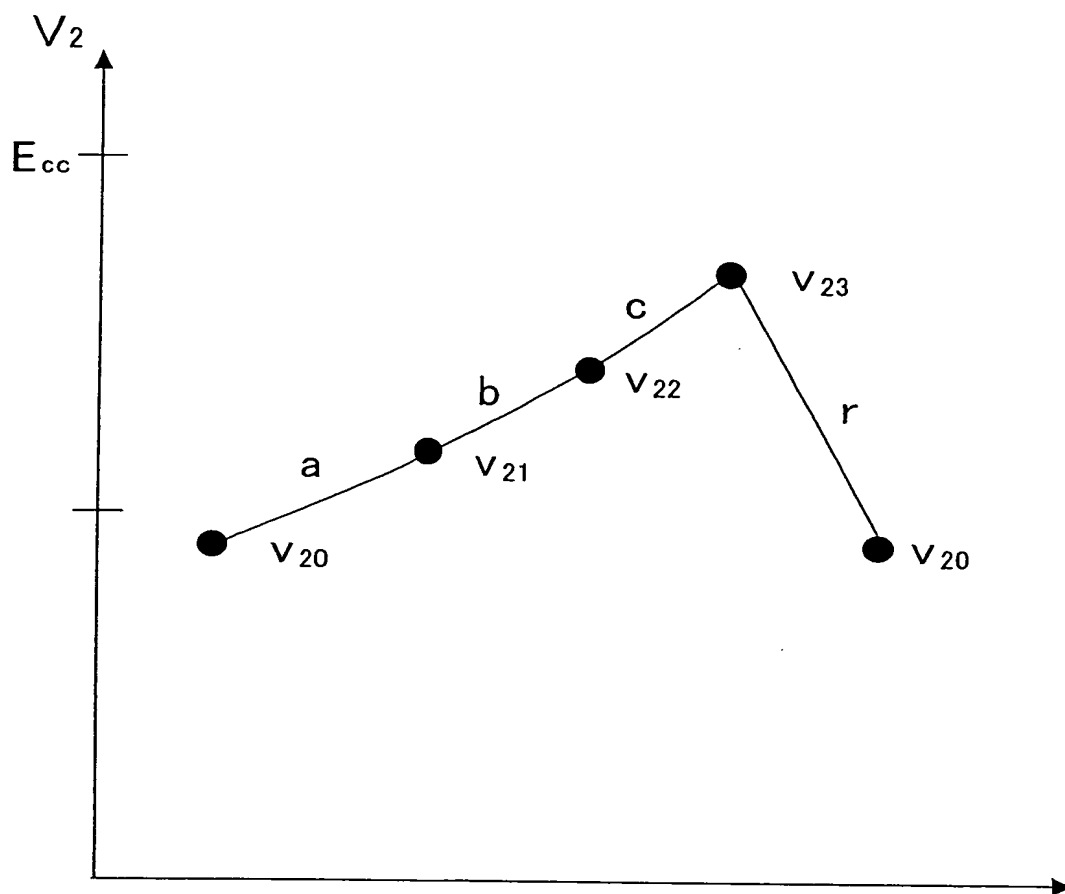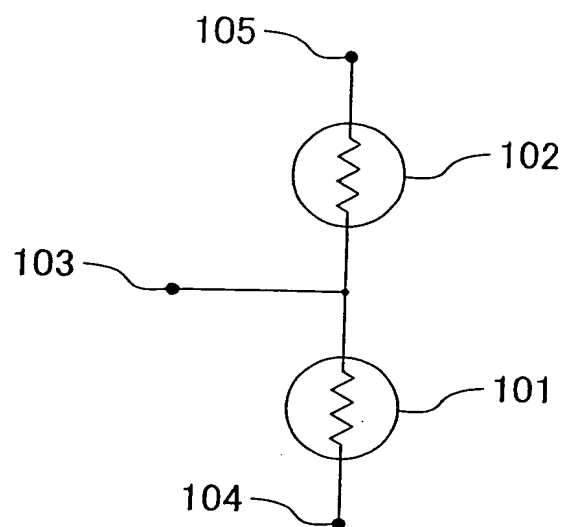| | Step 1 | | Step 2 | After initialization |
|---|---|---|---|---|
| Resistor 101 | 30kΩ | → 100Ω | 100Ω | R : Increase |
| Resistor 102 | 30kΩ | → 100Ω | 9kΩ | R : Decrease |
| Terminal 103 | GND | | GND | +2V |
| Terminal 104 | +2V | | GND | GND |
| Terminal 105 | −2V | | +2V | GND |

(b)

# FIG. 31

(a)



(b)
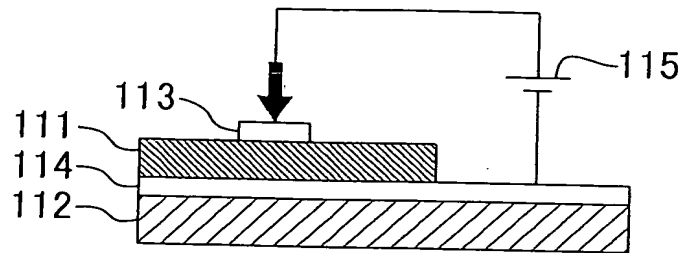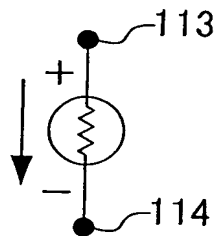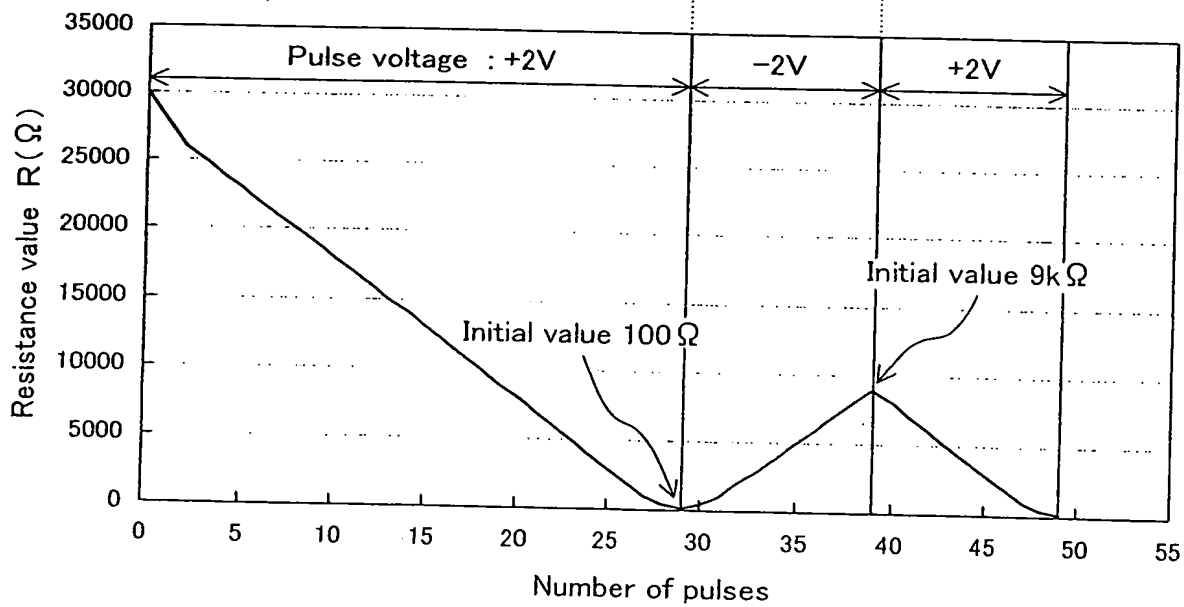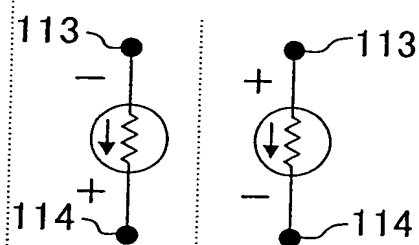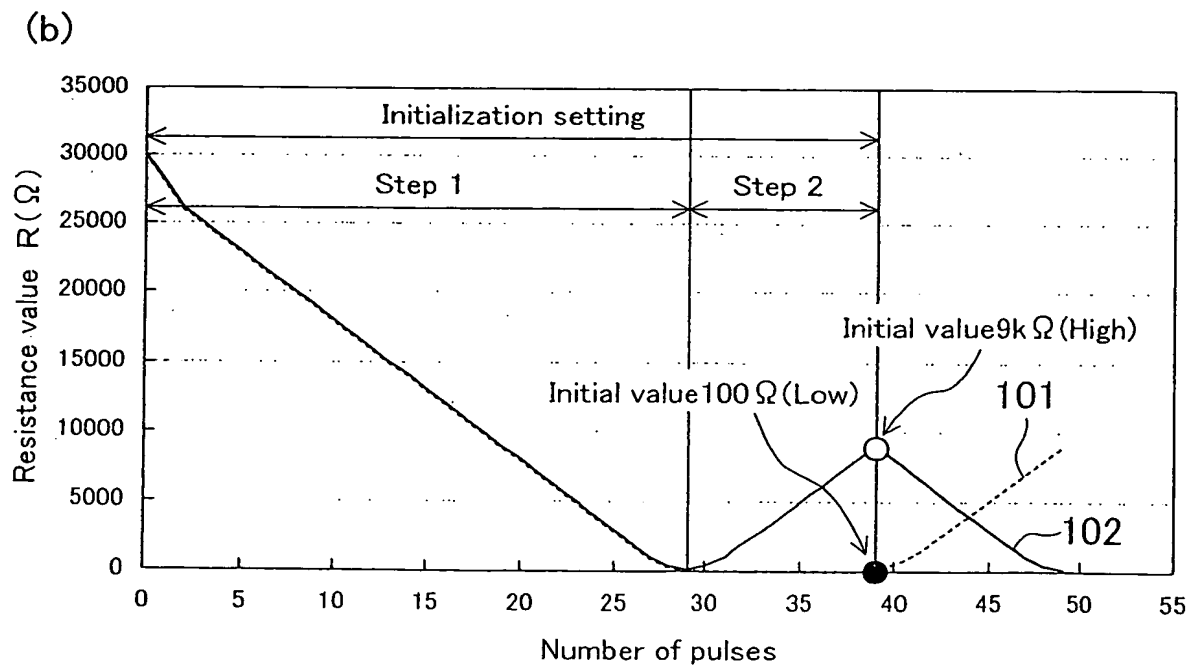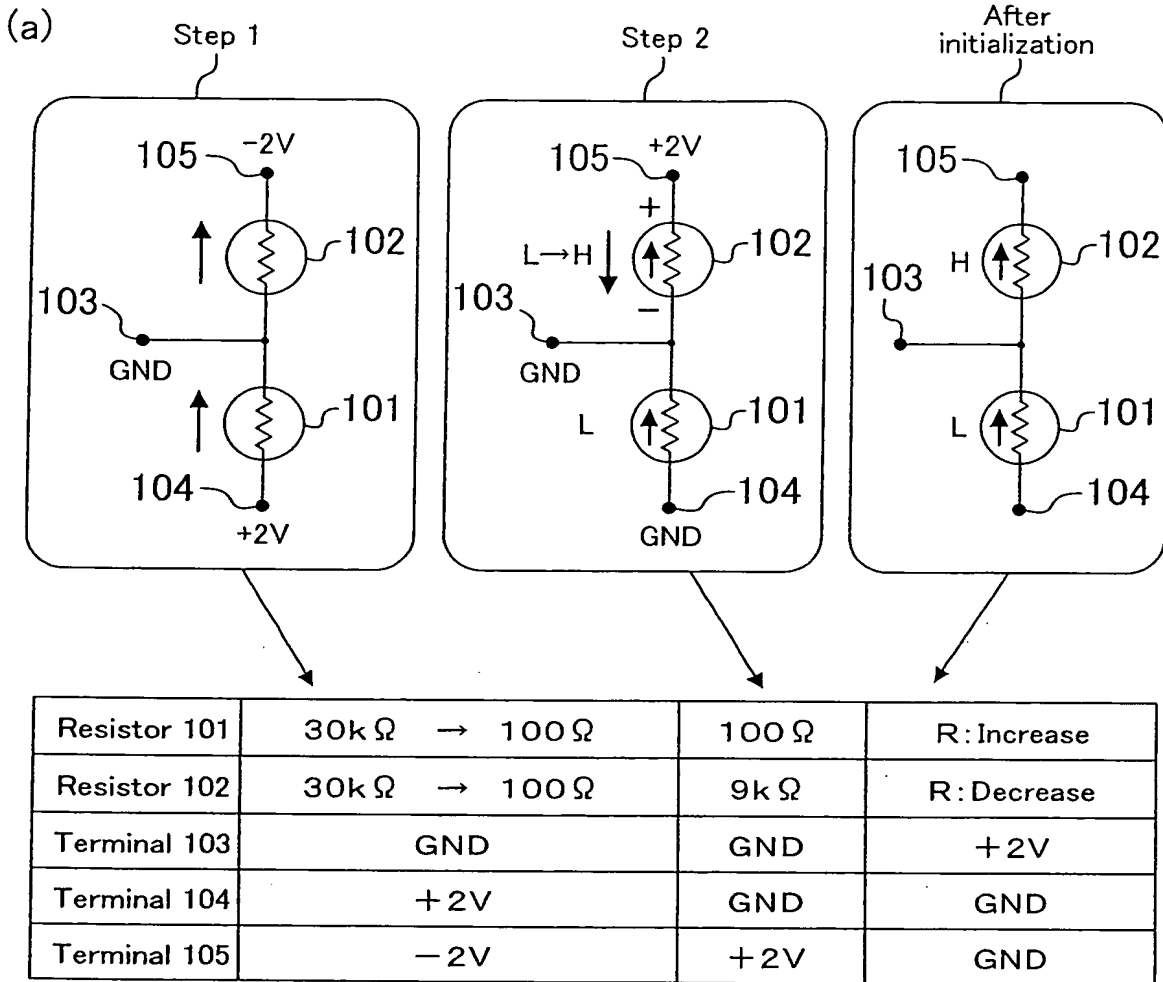


Number of pulses

# FIG. 32

# FIG. 33

(a) Resistance variation over number of pulses
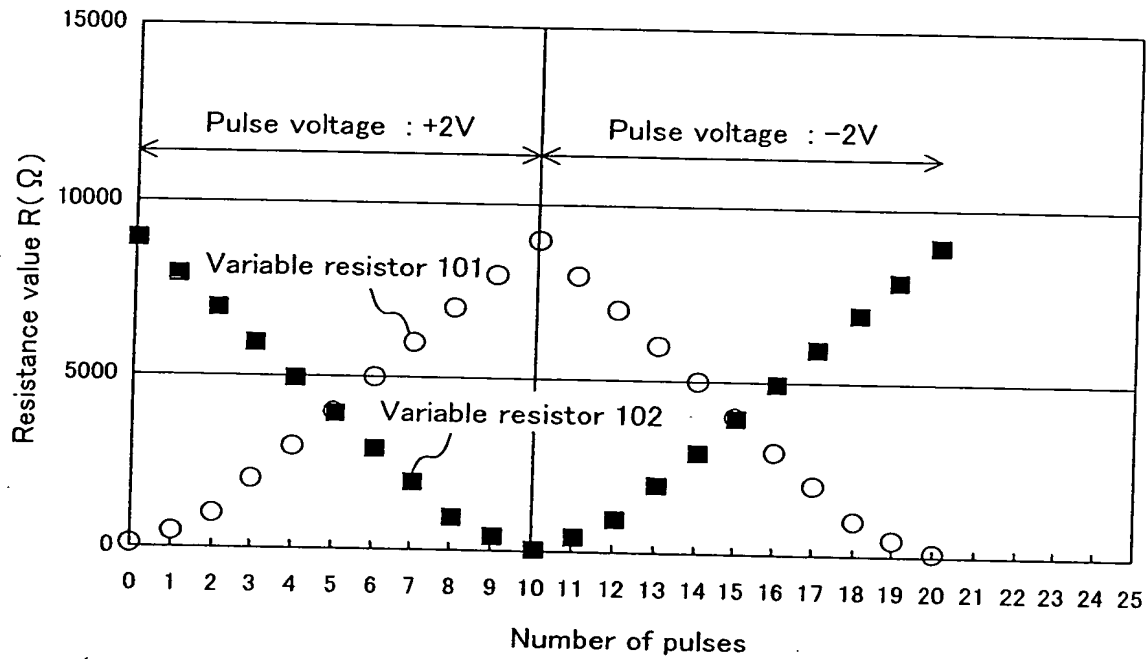


(b) Output voltage when reading recorded state

# FIG. 34

(a) Resistance variation over number of pulses



(b) Output voltage when reading recorded state

# FIG. 35

(a)



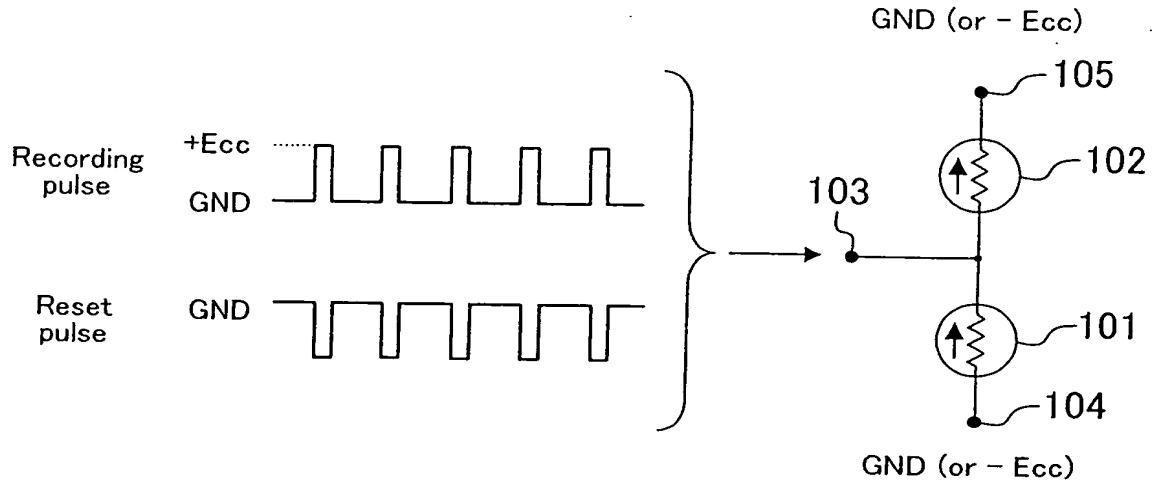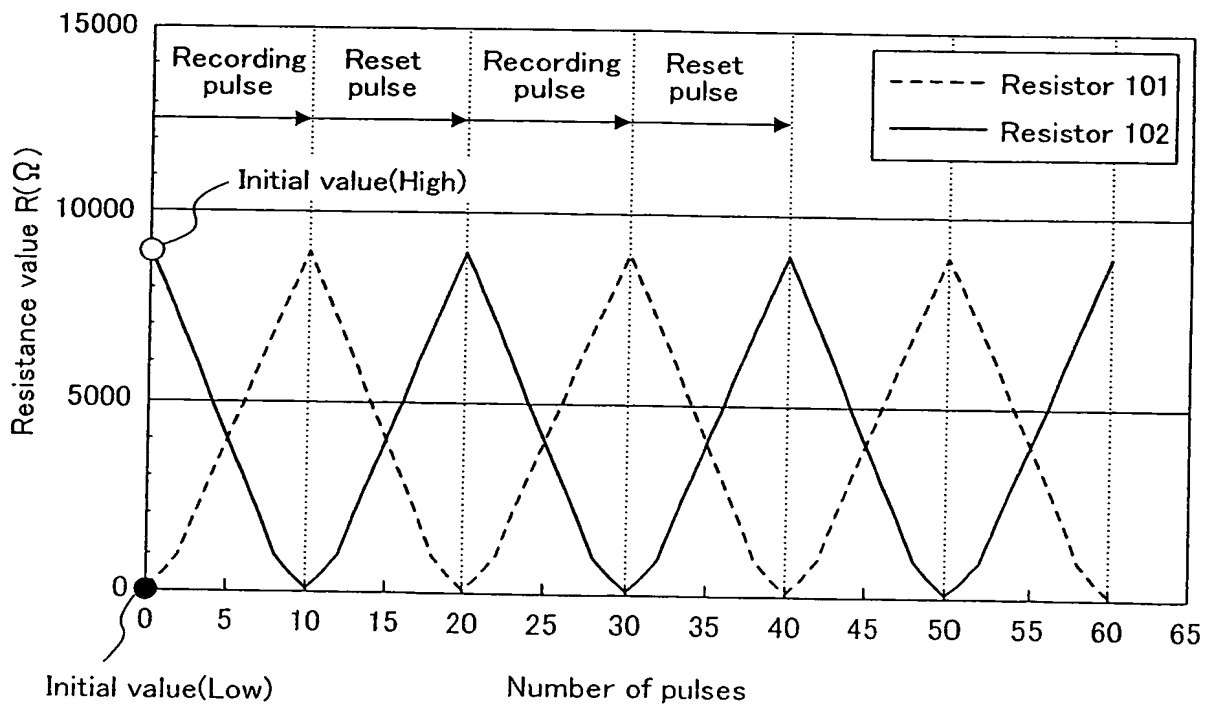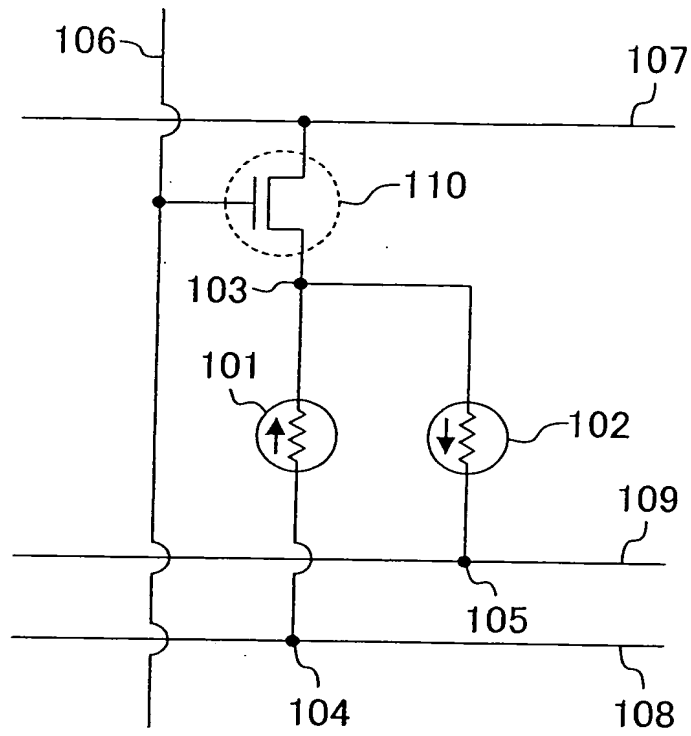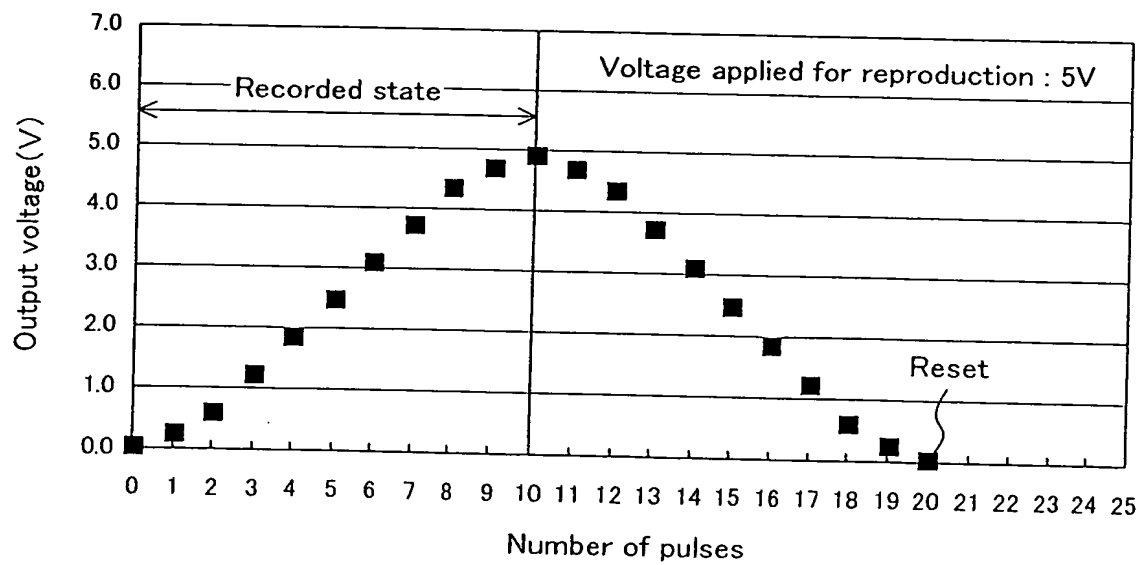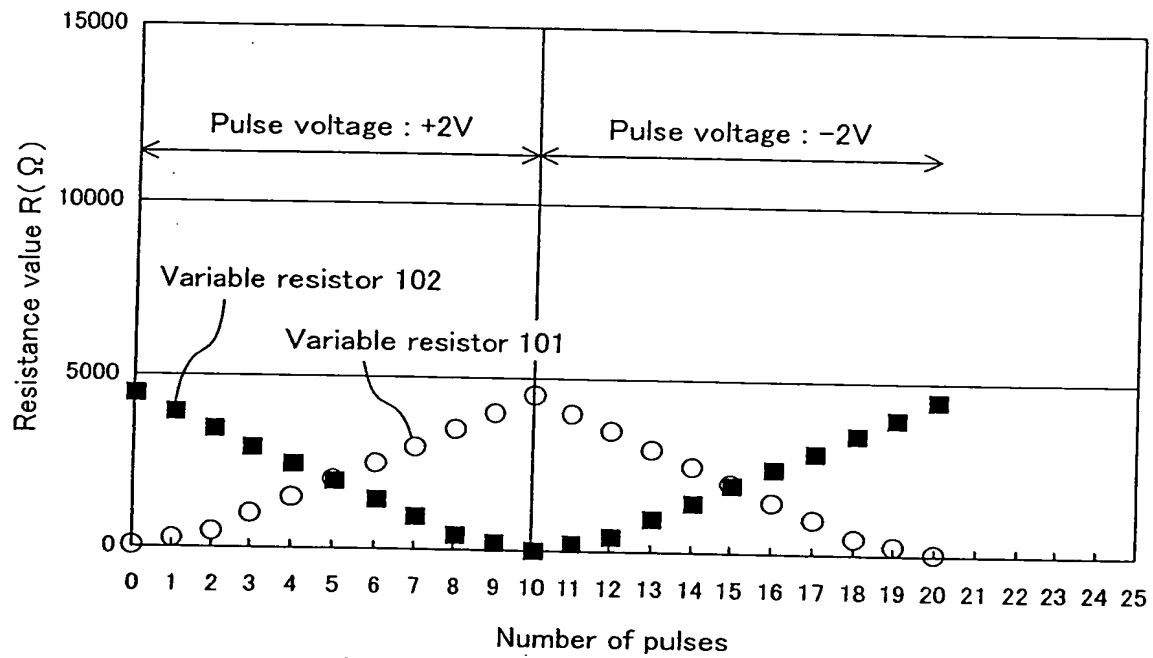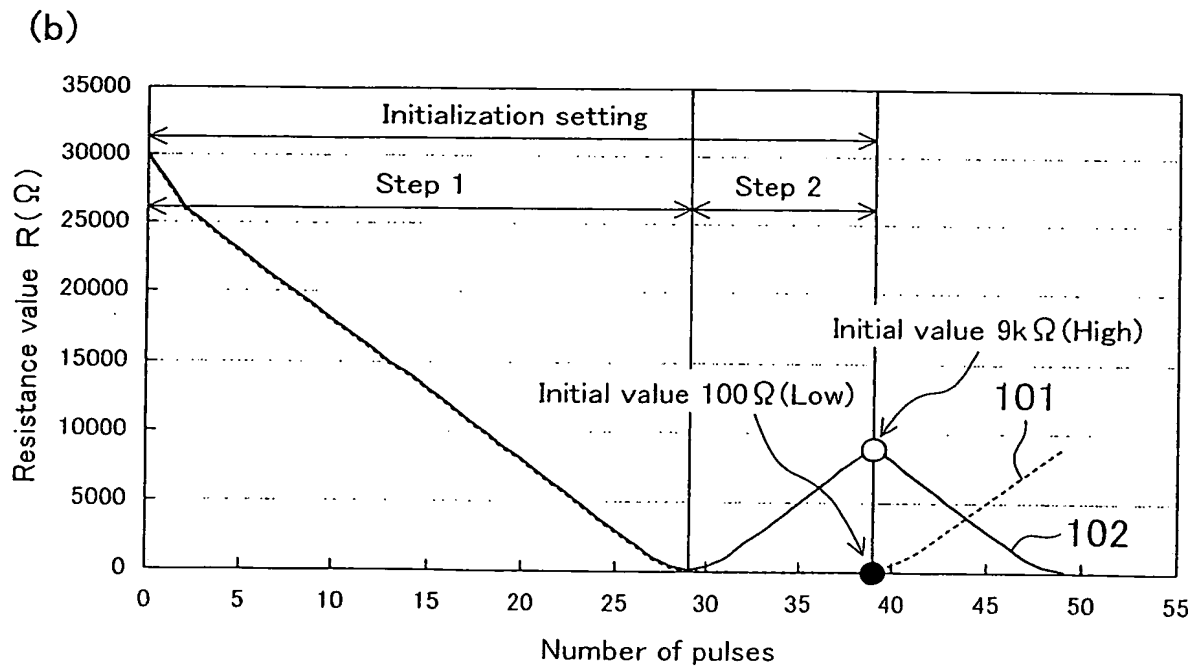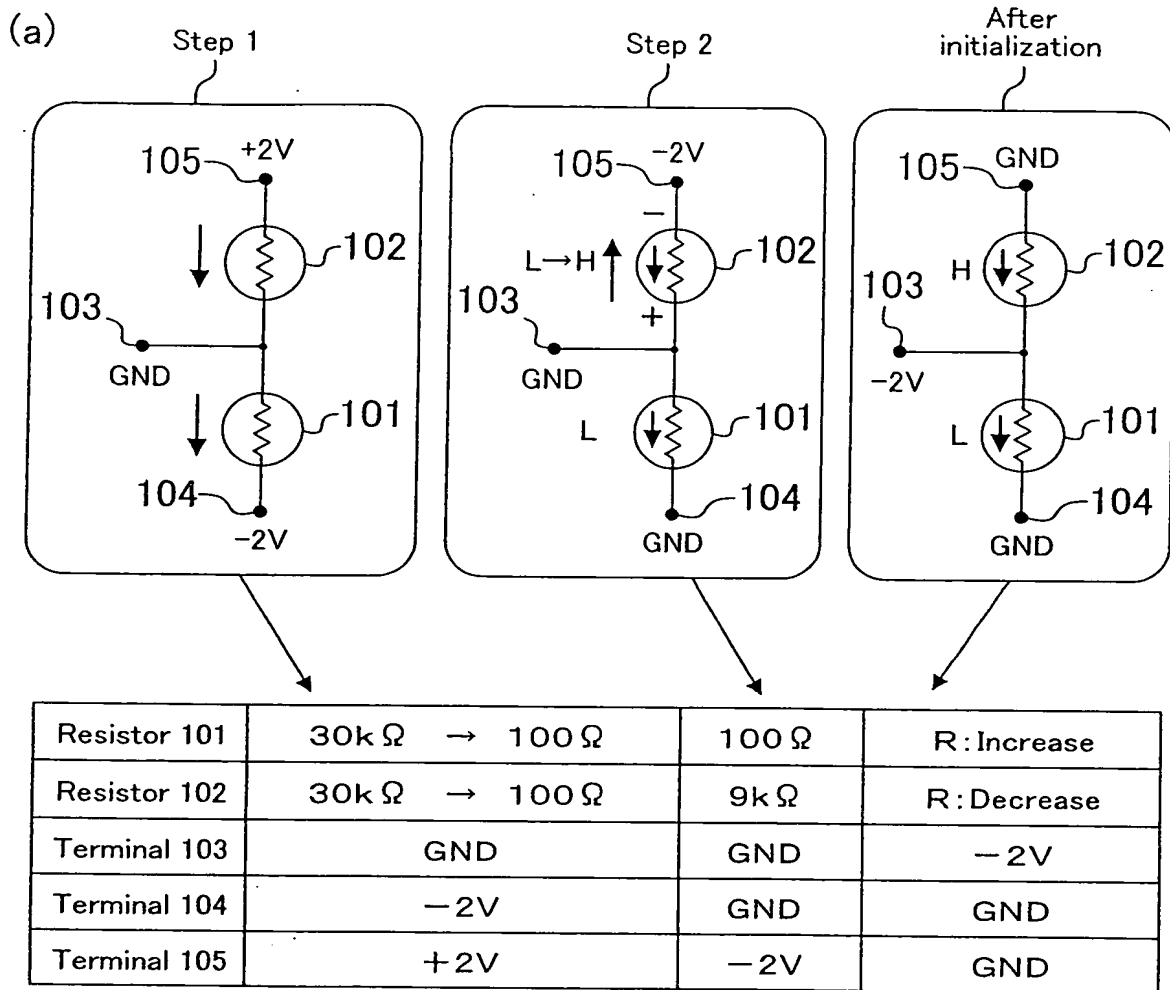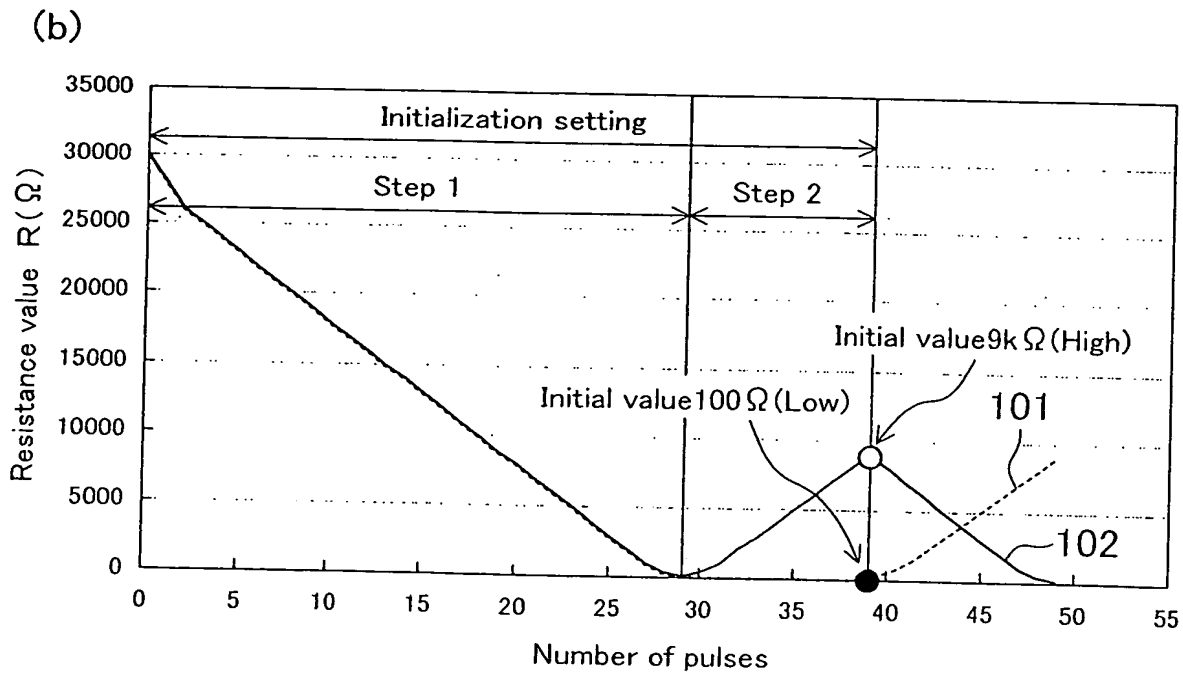| | Step 1 | | Step 2 | After initialization |
|---|---|---|---|---|
| Resistor 101 | 30kΩ | → 100Ω | 100Ω | R : Increase |
| Resistor 102 | 30kΩ | → 100Ω | 9kΩ | R : Decrease |
| Terminal 103 | GND | | GND | −2V |
| Terminal 104 | −2V | | GND | GND |
| Terminal 105 | +2V | | −2V | GND |

(b)

## FIG. 36

(a)



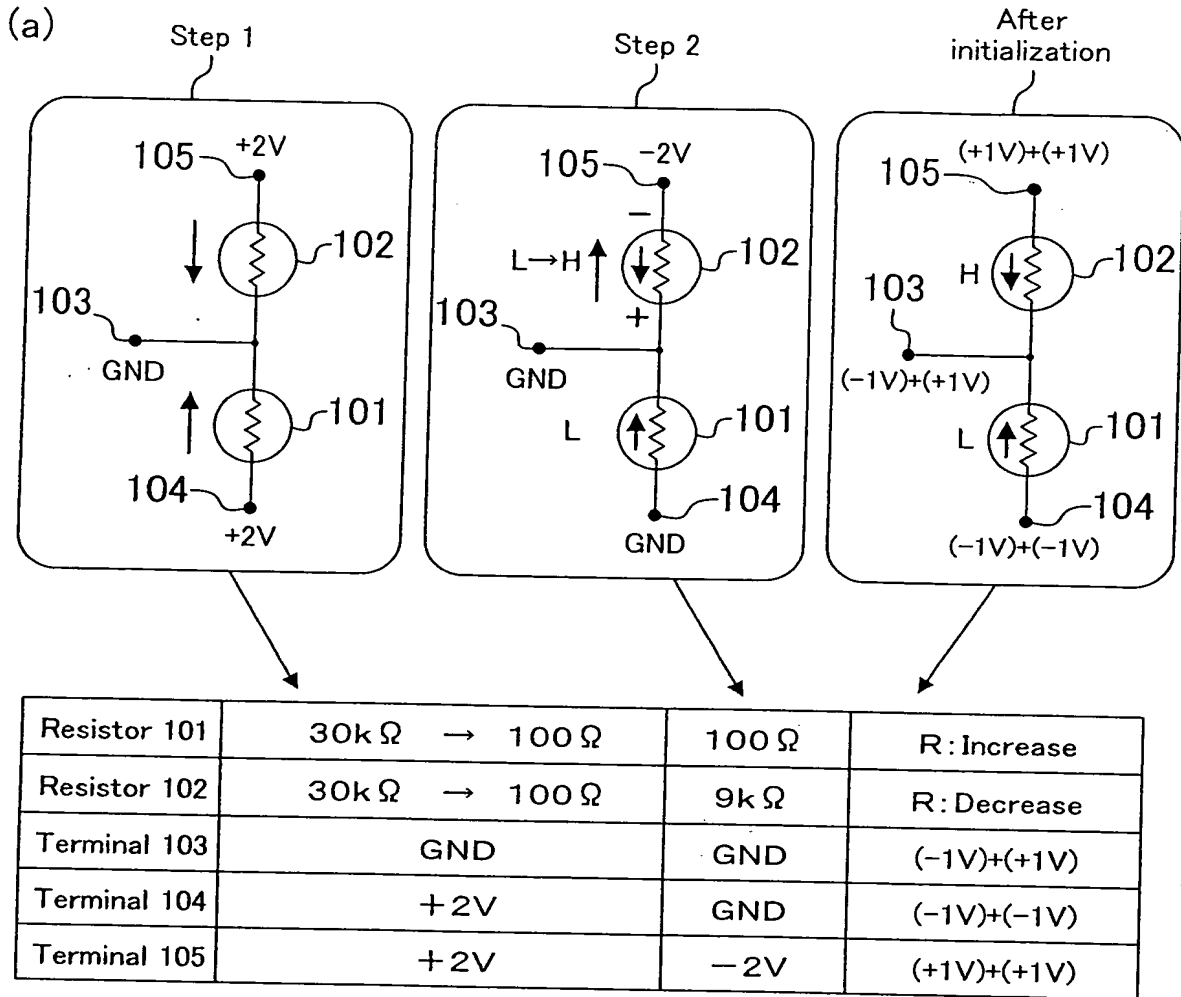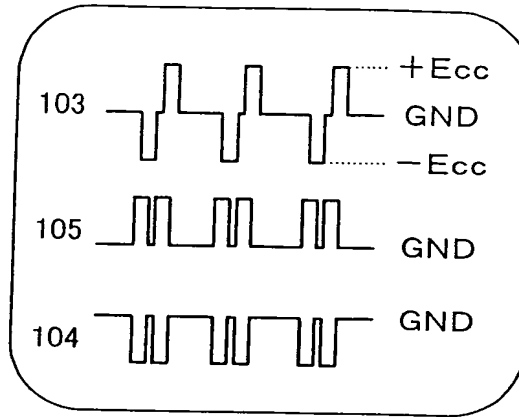| | Step 1 | | Step 2 | After initialization |
|---|---|---|---|---|
| Resistor 101 | 30kΩ | → 100Ω | 100Ω | R : Increase |
| Resistor 102 | 30kΩ | → 100Ω | 9kΩ | R : Decrease |
| Terminal 103 | GND | | GND | (-1V)+(+1V) |
| Terminal 104 | +2V | | GND | (-1V)+(-1V) |
| Terminal 105 | +2V | | -2V | (+1V)+(+1V) |

(b)
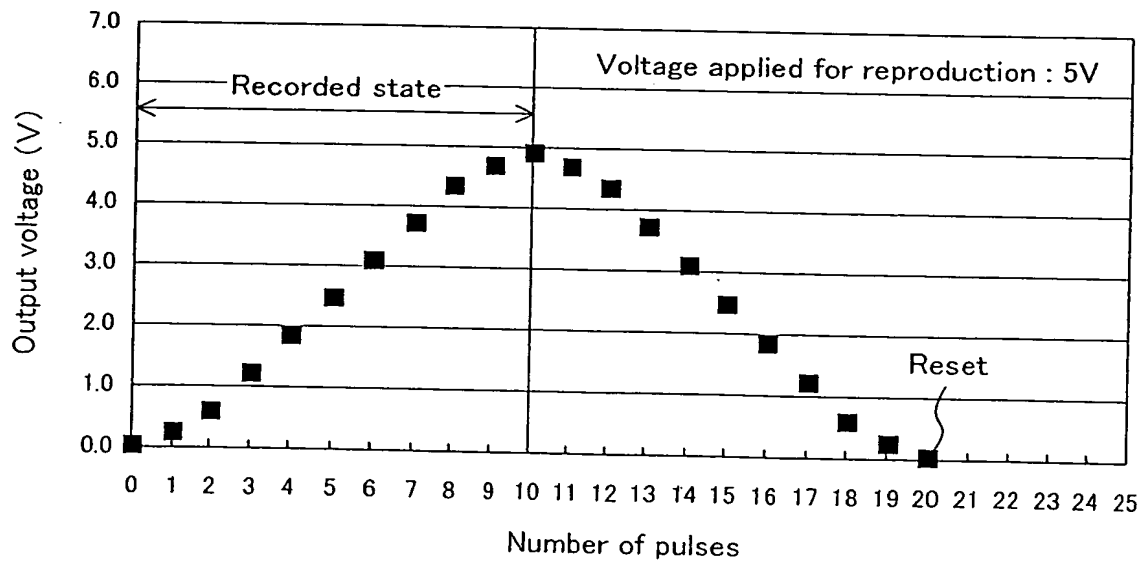
# FIG. 37

(a)

Recording operation



Reset operation



Electric pulse

(b)

FIG. 38

(a)



| | | | |
|---|---|---|---|
| Resistor 101 | 30kΩ → 100Ω | 100Ω | R : Increase |
| Resistor 102 | 30kΩ → 100Ω | 9kΩ | R : Decrease |
| Terminal 103 | GND | GND | (−1V)+(+1V) |
| Terminal 104 | −2V | GND | (+1V)+(+1V) |
| Terminal 105 | −2V | +2V | (−1V)+(−1V) |

(b)